An elliptical distribution of stars is not confined to the Hercules cluster. Counts for four other systems are summarized in Table III and plotted in figure 3. Three of them show unmistakable signs of elliptical form; the fourth, Messier 10, is a cluster with noticeably less condensation toward the center than usual. If the axes of symmetry in the others represent the projections of galactic-like planes, it is possible that in Messier 10 there is such a plane of symmetry inclined nearly 90° to the line of sight. The inclination to the equator of the projected major axis of Messier 13 is 152° (angle counted from *Following* through *North*). For Messier 2 and N. G. C. 5024 the inclination is 133° and 105°, respectively, while for Messier 15, which is across the Milky Way, it is 60° and is nearly parallel to the galactic plane.

[1] A bibliography of the more important of these investigations is given in *Mt. Wilson Contrib.* No. 115, (3–10), and No. 116, (4–8).

[2] Bailey, S. I., *Cambridge, Ann. Obs. Harvard Coll.*, **76**, (43–82).

[3] Shapley, H., *Observatory, London*, **39**, 1916, (452–456).

[4] Bailey, S. I., *Astr. and Astroph., Northfield, Minn.*, **12**, 1893, (689–692).

[5] *Washington, Carnegie Inst., Year Book*, **12**, 1913, (213); **13**, 1914, (258).

THE SHARE OF EGG AND SPERM IN HEREDITY

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1. Assumed Equivalence of Inheritance from Both Parents.—Practically all students of heredity are agreed that there is a general equivalence of inheritance from father and mother, and O. Hertwig (1892) cites this as one of the evidences that the chromosomes only contain inheritance material, or 'Erbmasse,' since they alone come in approximately equal volumes from the two parents. Indeed phenomena of Mendelian inheritance demonstrate that, with respect to those characters which usually distinguish the two parents, there is equivalence of inheritance from each, and where offspring resemble one parent more than the other they are probably as frequently patroclinous as matroclinous. Furthermore, the distribution of chromosomes in maturation, fertilization and cleavage is exactly parallel to the distribution of Mendelian factors, which practically demonstrates that the chromosomes are the seat of these factors.

This conclusion has led many students of heredity to regard the cytoplasm of the germ cells as of no significance in heredity. Both egg and sperm contain cytoplasm which is differentiated, in the former for the

nutrition of the embryo, in the latter for bringing the sperm into union with the egg; but in neither case is this differentiated cytoplasm directly concerned in heredity. The highly differentiated cytoplasm of the spermatozoon is either left outside the egg when its nucleus enters, or it undergoes de-differentiation within the egg; at the same time the egg cytoplasm ceases to form yolk, while the yolk which has been formed is gradually used up in the nourishment of the embryo. Consequently since these particular differentiations of the germ cells disappear after the union of egg and sperm it has been generally supposed that all cytoplasmic differentiations of these cells are wiped out at this time, and that the first differentiations of the new individual begin at the moment of fertilization in a wholly undifferentiated cytoplasm.

In the higher animals at least most of the cytoplasmic differentiations of the spermatozoon are lost after it enters the egg, though some differentiations such as centrosome, plastosomes and archiplasm may persist; however there is the most positive evidence that many differentiations of the egg cytoplasm persist and play an important part in embryonic differentiation.

2. *Egg Differentiations which persist in Embryo and Adult.*—(*1*) *Polarity.* The polarity of the egg invariably determines the polarity of the embryo and adult. In all animals the chief axis of the egg becomes the chief axis of the gastrula, and this becomes the chief axis of the adult in sponges and coelenterates (protaxonia), or, as in all other metazoa (heteraxonia), this axis is bent on itself by the greater growth of the gastrula on its posterior side so that the chief axis of the adult is a modification of the gastrular axis. In either case the polarity of the unfertilized egg determines the localization of developmental processes and ultimately the polarity of the developed animal.

(*2*) *Symmetry.* In most animals the egg is spherical in shape and appears to be radially symmetrical, nevertheless observation and experiment show that such eggs are sometimes bilateral, as is probably the case in Amphioxus, ascidians, fishes and frogs. In the case of the frog's egg it was long believed that the plane of bilateral symmetry was determined wholly and exclusively by the path of the spermatozoon within the egg; more recently it has been shown by Brachet (1911) that primary bilateral symmetry is present before fertilization, though after fertilization the plane of symmetry may be shifted into the path of the spermatozoon. It is probable that all bilateral animals come from eggs which show a similar primary bilaterality and that this differentiation precedes fertilization. In cephalopods and some insects all the axes and poles of the developed animal are already recognizable

in the egg before fertilization. Symmetry, therefore, as well as polarity is derived from the egg and not from the sperm.

(3) *Inverse Symmetry* (*Asymmetry*). In many animals the right and left sides of the body are not completely alike, and this is especially true of internal organs. This asymmetry is especially well developed in gasteropods in which certain organs of one side of the body are entirely lacking; some species or individuals have these asymmetrical organs on one side, others on the other side, and correspondingly the snail shell coils in a clock-wise direction in one case, an anticlock-wise direction in the other. It was discovered by Cramptom (1894) and Kofoid (1894) that in sinistral species the direction of certain cleavages of the egg (*viz.* the third to the sixth) was the reverse of the corresponding cleavages in dextral species and Conklin (1903) showed that the first and second cleavages also were in opposite directions in dextral and sinistral snails. Consequently the 'inverse symmetry' of these snails may be traced back through the later and earlier cleavage stages to the unsegmented egg itself which is inversely symmetrical in sinistral as compared with dextral forms.

(4) *Types of Egg Organization.* The polar differentiation of an egg is manifested particularly in the localization of different kinds of materials in different parts of the egg. These materials may be inert pigment or yolk, but their localization by the activity of the cytoplasm indicates a definite pattern of organization in the cytoplasm. This pattern of egg cytoplasm differs greatly in certain phyla, there being a coelenterate type, an echinoderm type, an annelid-mollusk type, and a chordate type. The type of egg organization foreshadows the type of adult organization; in ascidians for instance distinct cytoplasmic substances are found in the egg in the same relative positions and proportions as the ectoderm, endoderm, mesoderm, notochord and nervous system of the embryo.

That the fundamental pattern of egg cytoplasm is not influenced by the spermatozoon is proved by the following facts:

a. It exists before fertilization, or it appears so soon after that it could not have been caused by the sperm.

b. In heterogeneous fertilization the pattern of the egg is not changed by the foreign sperm.

c. Natural or artificial parthenogenesis demonstrates that this pattern exists in the absence of fertilization.

These as well as other facts such as the correspondence between the size of the egg and the size of the embryo (Morgan); the transmission of chromatophores and peculiarities of leaf coloration by the fe-

male and not by the male germ cells in plants (Baur, Shull); the transmission in the egg cytoplasm of fat stains, chemical substances, immunizing bodies and possibly parasites prove that, "at the time of fertilization the hereditary potencies of the two germ cells are not equal, all the early development, including the polarity, symmetry, type of cleavage, and the relative positions and proportions of future organs being predetermined in the cytoplasm of the egg cell, while only the differentiations of later development are influenced by the sperm. In short, the egg cytoplasm fixes the type of development and the sperm and egg nuclei supply only the details" (Conklin 1908).

Ontogeny begins with the differentiation of the egg in the ovary and not at the moment of fertilization; at the latter time some of the most general and fundamental differentiations have already occurred. Indeed the cytoplasm of the egg is the more or less differentiated body of the embryo.

3. Is Inheritance through the Egg Cytoplasm Non-Mendelian?—Whenever a character is transmitted as such through the egg cytoplasm and not as factors in the chromosomes of egg and sperm it is not inherited in Mendelian fashion. Thus if chromatophores are transmitted from generation to generation in the cytoplasm of the egg and are at no time influenced by the sperm, their mode of inheritance is non-Mendelian. If the polarity, symmetry and pattern of the egg do not arise during oogenesis, but are carried over unchanged from generation to generation they are also non-Mendelian characters. With regard to the polarity of the egg, it is not certain whether it is transmitted in this manner or not; but its symmetry and pattern of organization are evidently developed anew in each generation. It is a significant fact that in oogonia and spermatogonia the volume of the nucleus is sometimes greater than that of the cytoplasm, and in all cases it is relatively greater in early stages of the genesis of the sex cells than in later ones. In general the relative volume of nucleus and cytoplasm is a good measure of the differentiation of the latter. Most of the cytoplasmic differentiations of the egg and sperm arise during the genesis of those cells, just as in the case of tissue cells. Nerve cells and muscle cells differentiate under the influence of maternal and paternal chromosomes, and undoubtedly the same is true of most of the differentiations of egg and sperm; but while some of these egg differentiations persist in the new individual those of the sperm do not. Consequently, in each generation the egg contributes more than the sperm to ontogeny. There is cytoplasmic inheritance through the female only, but these cytoplasmic characters are themselves of biparental origin.

This is Mendelian inheritance though somewhat complicated by the fact that every ontogeny has its beginnings in the preceding generation. Therefore, the conclusion which I recently expressed (Conklin 1916) *viz.* that polarity, symmetry and pattern of egg organization are non-Mendelian characters, is not justified.

Somewhat similar phenomena have been described by McCracken (1909); and Toyama (1913) in silk worms and by several authors (Locke, Castle, *et al*) in the seed characters of maize, wheat, etc. McCracken found that when two races of the silk worm are crossed one of which produces one brood a year (univoltin) and the other two (bivoltin), the F_1 offspring are all like their mother and in the F_2 generation "the broods fail to follow both parents in the expected proportions. Therefore," she concludes, "the Mendelian law does not hold in this case." Castle (1910) has criticised this conclusion and has explained these results on the ground that voltinism is inherited through the egg and that univoltinism is a Mendelian dominant to bivoltinism. Toyama (1913) has described in detail the mode of inheritance of several egg characters of silk worms and has shown that whereas these seem to be non-Mendelian they are in reality Mendelian, "the cause of disturbance of the proper order being due to the fact of maternal inheritance, in which paternal characteristics remain dormant, even though dominant in the egg stage."

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A CONTRIBUTION TO THE PETROGRAPHY OF THE ISLAND OF BAWÉAN, NETHERLANDS INDIES

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The mountainous island of Bawéan, between Java and Borneo, was formerly a group of volcanoes, now extinct and considerably eroded. It is about 9 miles in diameter, and the highest peaks are 2000 feet above the sea. The original form of the cones and craters has disappeared,